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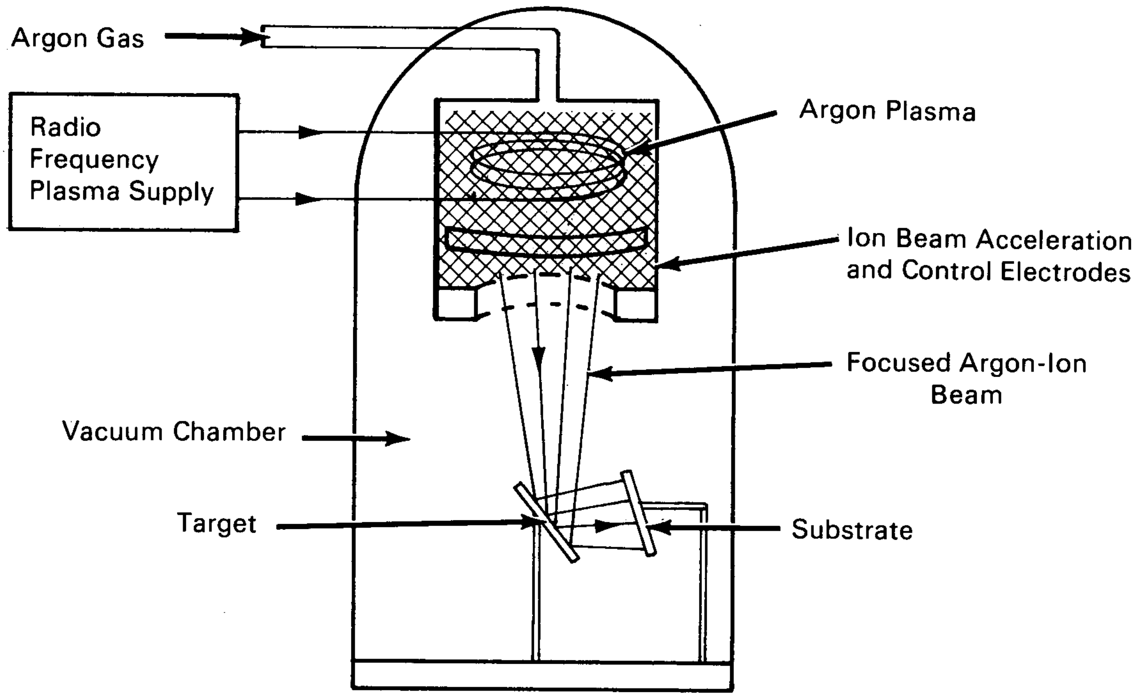
NASA TECH BRIEF

Epitaxial Crystalline Growth upon Cold Substrates



A method of growing thin films epitaxially on cold substrates has been developed. It was discovered that, by sputtering a material with a high-energy ion-beam bombardment, the molecules of the target's substance can be dislodged and ejected for subsequent deposition on a cold substrate of the desired crystallographic type and orientation. The orientation of the condensate to some finite thickness is controlled epitaxially by the substrate.

The pertinent features of this method are shown in the accompanying figure. A shaped argon ion beam, having a density of about 1 mA/cm^2 and energy up to 5 keV, is directed on a target material to be sputtered. The ejected material from the target is then collected on a suitable substrate located outside the immediate path of the ion beam. The temperature of the substrate is that of the ambient temperature of the vacuum chamber (approximately 75°C). In this specific experiment crystalline olivine (Mg_2SiO_4) is used as the target material, and the collection of the condensate is made upon a substrate of salt (NaCl) crystal. A layer of film 100 μ thick is deposited in one hour. An examination of the thin film with an electron microscope reveals that it is slightly crystalline, and could be

(continued overleaf)

identified as belonging to either the isometric or hexagonal crystal system. Since the olivine target is crystographically in the orthorhombic system, it is evident that a new material is deposited.

In the past epitaxial growth has been achieved by collecting condensates on substrates having elevated temperatures of about 250°C or higher. In this process thermal energy has been employed to produce condensates by evaporating and subsequently condensing materials on selected substrates. This energy provides the molecular mobility needed for crystal growth and orientation. In the instant method, however, the molecules sputtered from the target have kinetic energies of from 3 to 20 eV, in contrast to the thermal energies of about 0.1 eV in the case of the previously mentioned evaporants. This higher energy provides the needed mobility and assists in the epitaxial growth on the substrate. Although the principal advantage of this method initially appears to be the elimination of substrate heaters, it is likely that the production of epitaxial thin films having superior electrical and physical properties will be possible through its application.

Notes:

1. This development is primarily conceptual with some limited experimental data to demonstrate its feasibility.
2. Considering the trend to solid-state electronic components in the electronic industry, this discovery could lead to a substantial advance in the state of the art.
3. No further documentation is available. Inquiries may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B69-10494

Patent status:

No patent action is contemplated by NASA.

Source: Robert L. Lebduska of
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